



NASA SBIR Select 2012 Phase I Solicitation

Human Exploration and Operations

Human Exploration and Operations Mission Directorate Select Subtopics Topic E1 Sub Topics:

E1.01 High Power Electric Propulsion Systems

Lead Center: GRC

Participating Center(s): JPL, MSFC

The goal of this subtopic is to develop innovative technologies for high-power (15 kW -class) electric propulsion systems. High-power (high-thrust) electric propulsion may enable dramatic mass and cost savings for lunar and Mars cargo missions, including Earth escape and near-Earth space maneuvers. At very high power levels, electric propulsion may enable piloted exploration missions as well. Improved performance of propulsion systems that are integrated with associated power and thermal management systems and that exhibit minimal adverse spacecraft-thruster interaction effects are of interest. Innovations are sought that increase system efficiency, increase system and/or component life, increase system and/or component durability, reduce system and/or component mass, reduce system complexity, reduce development issues, or provide other definable benefits. Desired specific impulses range from a value of 2000 s - 3000 s for Earth-orbit transfers to and for planetary flagship missions. System efficiencies in excess of 50% and system lifetimes of at least 5 years (total impulse > 1 x 10⁷ N-sec) are desired. Specific technologies of interest in addressing these challenges include:

- Cathodes that address one or more of the following:
 - Long-life, high-current (100,000 hours).
 - Fast start.
 - Propellantless.
 - Operation on alternate propellants.
- Innovated designs for improved thruster performance and life.
- Electric propulsion systems and components for alternate fuels.
- Electrode thermal management technologies.
- Innovative plasma neutralization concepts.
- High-efficiency, lightweight power converters for high power (>10kW) DC discharge.
- Lightweight, low-cost, high-efficiency power processing units (PPUs) that accept variable input voltages of greater than 200V, including high temperature power electronics.
- Direct drive power processing units.
- Low-voltage, high-temperature wire for electromagnets.
- High-temperature permanent magnets and/or electromagnets.
- Advanced materials for electrodes and wiring.
- Highly accurate or fast acting propellant control devices and miniature flow meters.
- Superconducting magnets.

Note to Proposer: Subtopic S3.03 under the Science Mission Directorate also addresses in-space propulsion. Proposals more aligned with science mission requirements should be proposed in S3.03. For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path toward Phase II demonstration, and delivering a demonstration package for NASA testing at the completion of the Phase II contract. *Phase I Deliverables* - Identify and evaluate candidate technology applications to demonstrate their technical feasibility and show a path towards demonstration via bench or lab-level demonstrations. The technology concept at the end of Phase I should be at a TRL range of 3-4. *Phase II Deliverables* - Emphasis should be placed on developing and demonstrating the technology under simulated mission conditions. The proposal shall

outline a path showing how the technology could be developed into mission-worthy systems. The contract should deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract. The technology concept at the end of Phase II should be at a TRL range of 5-6.

E1.02 Nano/Micro Satellite Launch Vehicle Technology

Lead Center: KSC

Participating Center(s): ARC

The space transportation industry is in need of low-cost, reliable, on-demand, routine space access. Both government and private entities are pursuing various small launch systems and architectures aimed at addressing this market need. Significant technical and cost risk exist in new system development and operations, reducing incentives for private capital investment in this still-nascent industry. Public and private sector goals are aligned in reducing these risks and enabling the development of small launch systems capable of reliably delivering payloads to low Earth orbit. The Nano/Micro Satellite Launch Vehicle (NMSLV) will provide the nation with a new, small payload access to space capability. The primary objective is to develop a capability to place nano and micro satellites weighing up to approximately 20 kilograms into a reference orbit defined as circular, 400 to 450 kilometer altitude, from various inclinations ranging from 0 to 98 °. This subtopic seeks commercial solutions in the areas of nano and micro spacecraft launch vehicle technologies, with particular focus on higher risk entrepreneurial projects for dedicated nano and micro spacecraft launch vehicles and components. Proposals should include, but not be limited to, the following areas:

- Orbital booster designs of system/architectures capable of reducing the mission costs associated with the launching of small payloads to LEO. The designs should focus on the following:
 - Develop and implement technologies for small, lightweight, robust avionics packages for launch vehicle control, systems monitoring, autonomous flight termination, separation systems and TDRS transmitter to support the launch test.
 - Requirements (acceptable to range safety organizations) for Autonomous Flight Termination System(s) for Nano/Micro Launchers.
 - Develop and test the propulsion system for the NMLV by production reducing cost.
 - Development of a ground operations concept to show how the launch vehicle will be integrated, processed and launched.
- Performance predictions, cost objectives, and development and demonstration plans for the NMSLV.
- All proposed sub-orbital booster technologies should be traceable to an orbit-capable Small Launch Vehicle (SLV), whereby specific technologies are identified for Phase II development and test.

The NMSLV would be a smaller vehicle than the Pegasus launch vehicle, which is considered an SLV. For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path towards Phase II hardware/software demonstration with delivery of a demonstration unit or software package for NASA testing at the completion of the Phase II contract. *Phase I Deliverables* - Provide concept designs to include simulations and measurements, proving the proposed approach to develop a given product. Also required for all technologies are performance predictions, cost objectives, and development and demonstration plans for the NMSLV. Formulate and deliver a verification matrix of measurements to be performed in Phase II, along with specific quantitative pass-fail ranges for each quantity listed. The report shall also provide options for commercialization opportunities after Phase II.

- The concept designs should focus on the following:
 - Nano/Micro Launch vehicle avionics systems for launch vehicle control.
 - Requirements (acceptable to range safety organizations) for Autonomous Flight Termination System(s) for Nano/Micro Launchers.
 - Nano/Micro Launch vehicle TDRS Transmitters System(s).
 - Ground Processing concepts to include range locations.

The technology concept at the end of Phase I should be at a TRL of 2 to 4. *Phase II Deliverables* - Working engineering model of proposed Phase I components or technologies, along with full report on development and

measurements, including populated verification matrix from Phase I. Vehicle hardware shall emphasize launch cost reduction technologies, and possess sufficient design information to fabricate, integrate, and operate the selected high-risk component(s) for demonstration. Sub-orbital booster design is required as knowledge is gained through the critical component development process.

- Perform a full duration engine firing testing of each type of engine to be used on the Nano/Micro Launch Vehicle (NMSLV). Second stage engines should be tested in a vacuum.
- Conduct a guided sub-orbital booster flight test of the proposed NMLV.
- Perform performance predictions for orbital flight, cost objectives, and development and demonstration plans for the NMSLV orbital flight.
- Ground operation plan and support level for an orbital test flight to include range locations.
- Development of the Nano/Micro Launch vehicle avionics suite to include launch vehicle control, systems monitoring, separation systems and TDRS transmitter.
- Requirements (acceptable to range safety organizations) and design for Autonomous Flight Termination system(s) for Nano/Micro Launchers.
- All proposed sub-orbital booster technologies should be traceable to an orbital capable NMLV, whereby specific technologies are identified for Phase III development and orbital test.

The technology concept at the end of Phase II should be at a TRL of 7.

E1.03 International Space Station Utilization

Lead Center: JSC

Participating Center(s): ARC, GRC, KSC, MSFC

NASA is investigating the near- and mid-term development of highly-desirable systems and technologies that provide innovative ways either to leverage existing ISS facilities for new scientific payloads or to provide on orbit analysis to enhance capabilities. Current utilization of the ISS is limited by available upmass, downmass, and crew time as well as by the capabilities of the interfaces and hardware already developed. Innovative interfaces between existing hardware and systems, which are common to ground research, could facilitate both increased, and faster, payload development. Technologies that are portable and that can be matured rapidly for flight demonstration on the International Space Station are of particular interest. Desired capabilities include, but are not limited to, the below examples:

- Providing additional on-orbit analytical tools. Development of novel instruments for on-orbit analysis of plants, cells and small mammals are desired. Instruments to support studies of bone and muscle loss, multi-generational species studies and cell and plant tissue are desired. Providing flight qualified hardware that is similar to commonly used tools in biological and material science laboratories could allow for an increased capacity of on-orbit analysis thereby reducing the number of samples which must be returned to Earth. Examples of tools that will reduce downmass or expand on-orbit analysis include: a mass spectrometer; an atomic force microscope (for biological and material science samples), non-cryogenic sample preservation systems; autonomous in-situ bioanalytical technologies; microbial and cell detection and identification systems; and fluidics and microfluidics systems to allow autonomous on-orbit experimentation and high throughput screening.
- Technologies are desired to ensure that microbial content of the air and water environment of the crew habitat falls within acceptable limits and life support system is functioning properly and efficiently. Required technology characteristics include: 2 year shelf-life; functionality in microgravity and low pressure environments (~8 psi). The technologies require significant improvements in miniaturization, reliability, life-time, self-calibration, and reduction of expendables. Microbial Analysis should cover identification and quantification.
- Providing a Magnet Processing Module (MPM) to enable materials research aboard ISS. Development of a Magnet Processing Module (MPM) for installation and operations in the Materials Science Research Rack (MSRR) would enable new and improved types of materials science investigations aboard the ISS. Essential components of the MPM include an electromagnet, which can provide a field strength up to 0.2 Tesla and a high temperature insert, which can provide directional solidification processing capability at

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- temperatures up to 1500 °C. Efforts should focus on development of the following:
- An electromagnet that can generate the required field with the following properties:
 - Two coils each receiving 120 Vdc @ 10A (power consumption /= 184 mm.
 - Length = 239 mm.
 - Heat dissipation via liquid coolant loop.
 - Shielding to limit emissions to 3.16 Gauss at a distance measured 70 mm from the outer surface of the magnet.
 - A high temperature insert with a maximum outer diameter < 184 mm that is capable of processing a sample 26 mm (diameter) by 200 mm (length) in a partial vacuum environment of 0.7 Pa . Areas to be addressed include:
 - The number of zones (hot, cold, gradient) required for processing.
 - Heating elements vs. power consumption.
 - Selection and placement of insulations.
 - Selection, type, quantity, and placement of temperature measuring devices suitable for the operating temperature range. Adjustable autonomous control software that supports safe operation with low-bandwidth, intermittent command communication loop with varying latencies > 10 sec.

Proposals may address any one or a combination of the above or related subjects. The existing hardware suite and interfaces available on ISS may be found at the following link:

(http://www.nasa.gov/mission_pages/station/science/experiments/Discipline.html [1]). For all above technologies, research should be conducted to demonstrate technical feasibility and prototype hardware development during Phase I and show a path toward Phase II hardware and software demonstration and delivering an engineering development unit or software package for NASA testing at the completion of the Phase II contract that could be turned into a flight unit with minimal additional investment. *Phase I Deliverables* - Written report detailing evidence of demonstrated prototype technology in the laboratory or in a relevant environment and stating the future path toward hardware and software demonstration on orbit. The technology concept at the end of Phase I should be at a TRL of 5-6. *Phase II Deliverables* - Emphasis should be placed on developing and demonstrating hardware and/or software prototype that can be demonstrated on orbit (TRL 8), or in some cases under simulated mission conditions. The proposal shall outline a path showing how the technology could be developed into mission-worthy systems. The contract should deliver an engineering development unit for functional and environmental testing at the completion of the Phase II contract.

High Power Electric Propulsion Systems Topic E1.01

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Sub Topics:

Nano/Micro Satellite Launch Vehicle Technology Topic E1.02

The space transportation industry is in need of low-cost, reliable, on-demand, routine space access. Both government and private entities are pursuing various small launch systems and architectures aimed at addressing this market need. Significant technical and cost risk exist in new system development and operations, reducing incentives for private capital investment in this still-nascent industry. Public and private sector goals are aligned in reducing these risks and enabling the development of small launch systems capable of reliably delivering payloads to low Earth orbit. The Nano/Micro Satellite Launch Vehicle (NMSLV) will provide the nation with a new, small payload access to space capability. The primary objective is to develop a capability to place nano and micro satellites weighing up to approximately 20 kilograms into a reference orbit defined as circular, 400 to 450 kilometer altitude, from various inclinations ranging from 0 to 98 °. This subtopic seeks commercial solutions in the areas of nano and micro spacecraft launch vehicle technologies, with particular focus on higher risk entrepreneurial projects for dedicated nano and micro spacecraft launch vehicles and components. Proposals should include, but not be limited to, the following areas:

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 - Requirements (acceptable to range safety organizations) for Autonomous Flight Termination System(s) for Nano/Micro Launchers.
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- The concept designs should focus on the following:
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 - Requirements (acceptable to range safety organizations) for Autonomous Flight Termination System(s) for Nano/Micro Launchers.
 - Nano/Micro Launch vehicle TDRS Transmitters System(s).
 - Ground Processing concepts to include range locations.

The technology concept at the end of Phase I should be at a TRL of 2 to 4. *Phase II Deliverables* - Working engineering model of proposed Phase I components or technologies, along with full report on development and measurements, including populated verification matrix from Phase I. Vehicle hardware shall emphasize launch cost reduction technologies, and possess sufficient design information to fabricate, integrate, and operate the selected high-risk component(s) for demonstration. Sub-orbital booster design is required as knowledge is gained through the critical component development process.

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The technology concept at the end of Phase II should be at a TRL of 7.

Sub Topics:

International Space Station Utilization Topic E1.03

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